SONY BASIC VIDEO RECORDING COURSE
BOOKLET #5

TAPE TRANSPORTS

SONY®

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INTRODUCTION

In this lesson we are concerned with the movement and guidance of tape as it flows past the stationary and rotating components that sense the magnetic patterns recorded on the tape surface. We will look at the source of driving power, the motors, and the systems used to guide and control tape flow. Finally, you will see some of the basic considerations in the automatic tape-threading systems used in cassette machines.
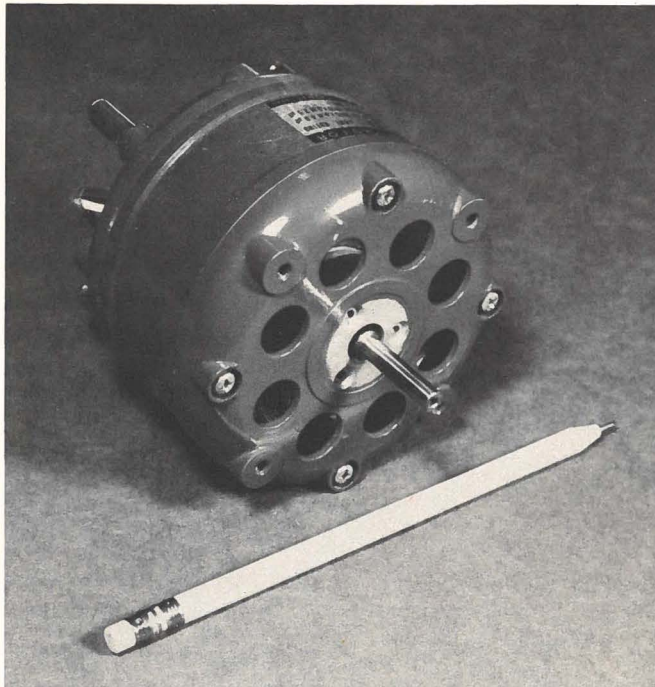
1. VTR DRIVE MOTORS

The motors used in VTRs apply driving torque to the scanner, the capstan and the reel tables. Torque is often transferred from the motor shaft to the driven member by means of belts and pulleys. However in some scanner systems the shaft of a separate motor is coupled directly to the rotating platform on which the video heads are mounted. Motors are also used to drive the threading-unthreading mechanism in cassette machines.

Motors can be classified broadly into two categories—a-c and d-c types. A-c motors are common in machines designed to operate from the power mains. The types used in VTRs make use of the extreme frequency accuracy of the power available in most advanced countries to yield highly accurate rotational speeds. These motors are also extremely rugged and reliable as they have no need for commutators and brushes.

Direct current motors are a necessity in portable, battery-powered equipment. However, d-c motors are generally much smaller and lighter, lend themselves easily to servo control and provide high starting torque. It is for the last reason that d-c motors are commonly used in the threading-unthreading drive systems used in cassette machines that are normally designed to operate from the power mains.
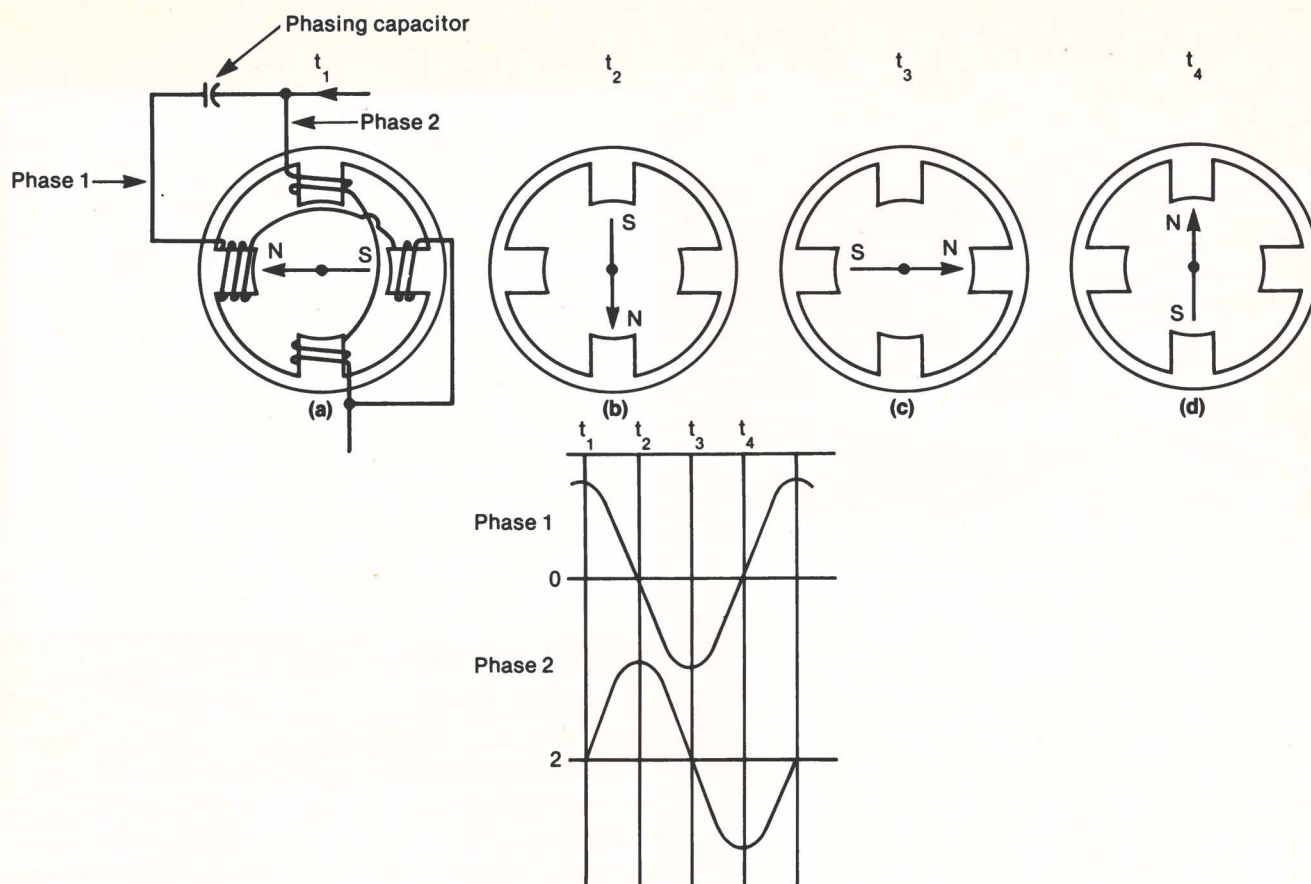

Fig. 1. A-C hysteresis motor.

Fig. 2. Field rotation in a 4-pole, 2-phase motor.

A-C Motors. The type of a-c motor in common use in VTRs is the 8-pole hysteresis motor. Fig. 1. shows an example of such a motor. The outstanding attribute of the hysteresis motor is that its rotational speed is synchronized with the power-line frequency over a wide range of mechanical loads. Unlike the conventional a-c motors found in appliances such as washers, dryers, oil burners, and the like, the hysteresis motor has no "slip". Conventional motors must run below synchronous speed to develop the electromagnetic reaction field in the rotor. For example, a common appliance motor turns at 1725 rpm even though the field rotates at 1800 rpm. But the rotor in a hysteresis motor is a permanent magnet. It reacts with the rotating field at all times.

The field of the hysteresis motor is made to rotate by shifting the phase of the current supplied to one of the sets of pole pairs. Fig. 2. shows the field rotation in a simple four-pole motor. By proper choice of the series capacitor the current in the second pair of field coils can

be made to lead the current in the first pair by 90°. Thus, at time t_1 in the waveform diagrams the polarity of the field will be as shown. At t_2, the current in the phase-shifted field has dropped to zero, the vertical field peaks in current, and the polarity of the field is as shown in (b) of the figure. At time t_3 the current in the horizontal fields is reversed, and so is the polarity of the magnetic field. One quarter cycle later the current and fields of the vertical fields will have reversed. Thus, in the time taken for one cycle, the motor field has made one complete turn. The speed of this motor is 3600 rpm, which is determined by the formula

$$S \text{ (rpm)} = \frac{120 \times \text{line frequency}}{\text{No. of poles per phase}}$$

The four pole motor depicted in Fig. 2. has 2 poles per phase.

Thus:

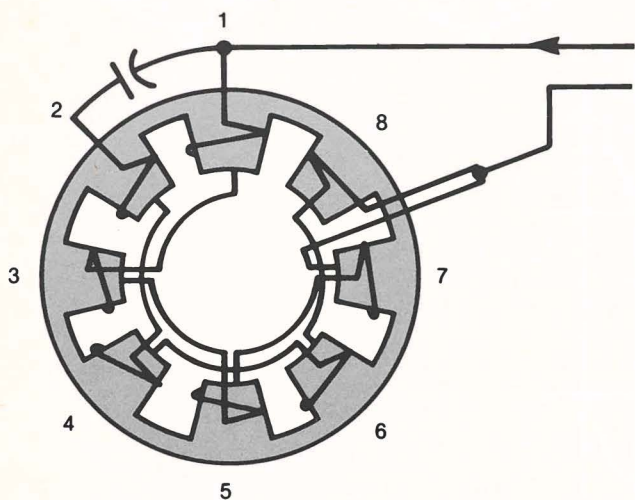$$S = \frac{120 \times 60}{2} = 3600 \text{ rpm (60 rps)}$$

Fig. 3. Stator winding in 8-pole 2-phase motor.

Fig. 4. 8-pole hysteresis motor disassembled to show rotor and stator.

By doubling the number of poles to four per phase, eight in all, the field will rotate a half turn in the time taken for a complete a-c cycle. Consider the peak in field current to move from pole-to-pole at 1/4 cycle intervals, just as was shown in Fig. 2. But now the peak will progress only halfway around in the same period. See Fig. 3. Hence the speed of the eight-pole motor is 1800 rpm when operated from the 60-Hz power mains.

Fig. 4. shows a close-up of the stator (field windings) and rotor of a typical VTR hysteresis motor. The field coils overlap progressively. There appears to be 16 poles in total, but each coil encircles a pair of adjacent pole pieces.

Phase shift between the two sets of field coils is achieved by a non-polarized electrolytic capacitor. In the unit shown in Fig. 4. a 2.5 μF capacitor is required to secure the needed phase shift when the unit is operated from 60 Hz mains. This value must be increased to 3.7 μF if the motor is to be operated from 50 Hz power; speed is then 1500 rpm.

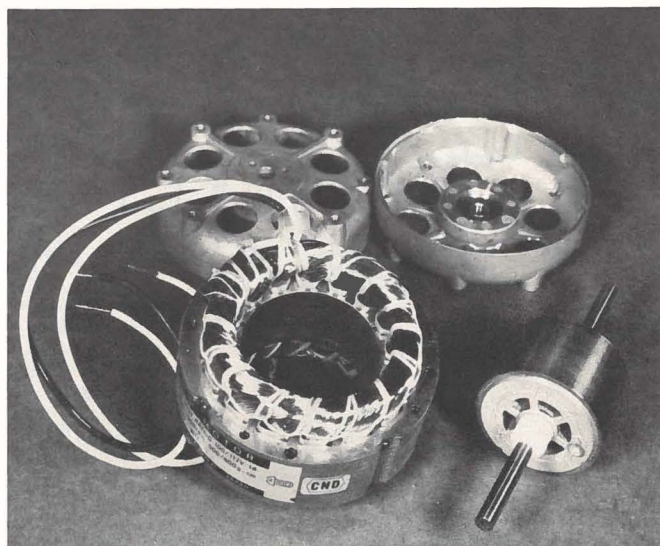Frequently, provision is made for operation on either 60- or 50-Hz power. In this case the change in phase-shift capacitance is achieved by altering jumper connections at a terminal board. Fig. 5. shows an example in an early U-matic deck (VP-1000).

Conversion from 60 Hz to 50 Hz power also requires changes in pulley ratios so that tape speed and scanner speed stay the same, even though motor speed changes from 1800 rpm to 1500 rpm. Thus a VTR designed to work on American TV standards (60 fields per second) but modified to work on the power available in Europe, must have its phasing capacitance changed as well as the pulley ratios between the motor and the scanner, and the motor and the capstan.

Hysteresis motors are extremely rugged and reliable. The types used in VTRs employ ball bearings so there is little service required due to wear. Many are equipped with an internal fuse that opens when excessive heat is generated in the stator windings due to electrical or mechanical failure. This fusible link is not replaceable and the entire motor must be replaced should the link open. This safety feature is designed to prevent damage to other components and fire hazards should the motor be subjected to prolonged overloads.
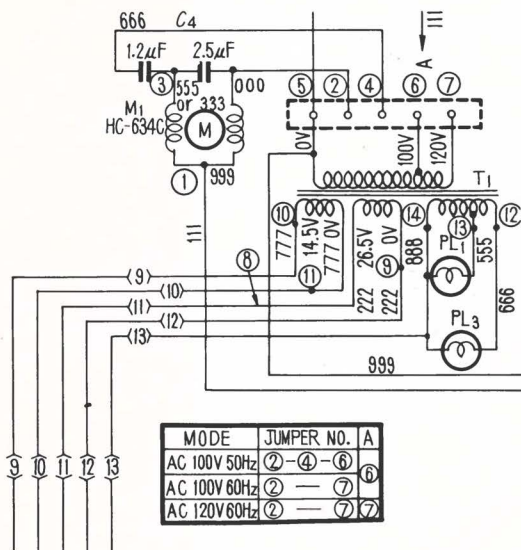
Fig. 5. Terminal board facilitates voltage tap changes on power transformer, and changes in total phasing capacitance to adapt motor to 50 or 60 Hz power.

MODE	JUMPER NO.	A
AC 100V 50Hz	②–④–⑥	⑥
AC 100V 60Hz	② — ⑦	
AC 120V 60Hz	② — ⑦	⑦

(a)

(b)

Fig. 6. Electromagnetic brake used in braking drum servos. Field is stationary.

Nonsynchronous a-c motors are not used in VTRs, but it is worth looking at them briefly because the electromagnetic braking system used in many scanner servos is similar in a reverse sort of way. In a squirrel cage motor of the type used in appliances the rotor consists of a mass of laminated iron with conductor bars around the circumference. The field is made to rotate in the same way as you have seen for the hysteresis motors. As the flux field cuts the conductors of the rotor, the rotor develops a magnetic field of its own and this magnet is forced to follow the field just as the permanent magnet in the hysteresis motor. The difference is that there has to be relative motion between the rotor and the field; if they both turn at the same rate the conductor bars would not be cut by the flux lines and no rotor field would be developed. Thus the squirrel cage motor "slips"; it runs below synchronous speed.
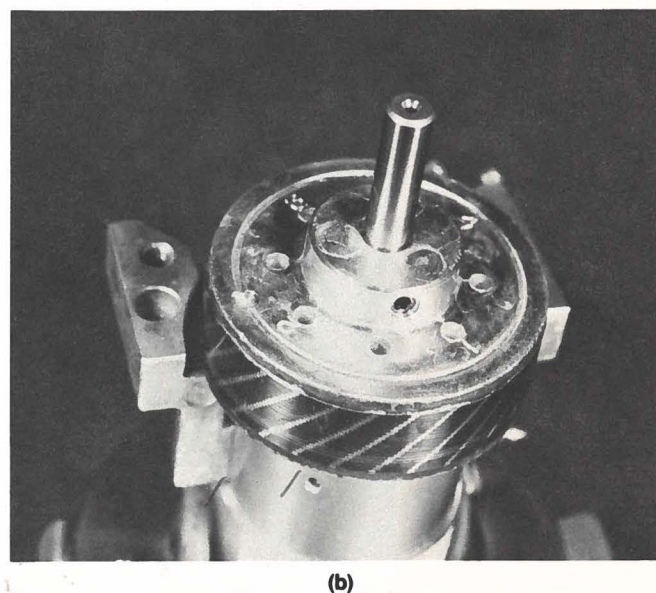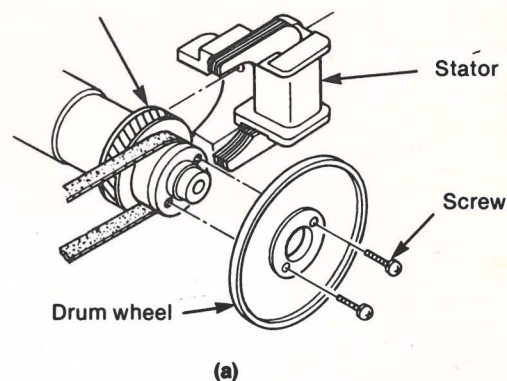
The electromagnetic brake used in braking-type scanner servos has a rotor very much like that of the squirrel cage motor. See Fig. 6. The difference is that the shaft of the rotor is driven by a belt and pulley arrangement from the main a-c motor. The field is static, d-c, and its strength is governed by the servo system. Thus the unit operates opposite to that of a motor and in fact works like a controllable brake. In braking servo systems, as you will see in later lessons, the mechanical drive to the scanner is arranged to turn the scanner at a speed above that of its expected steady-static speed. Thus, by increasing or decreasing brake current the scanner can be made to speed up or slow down to the correct value.
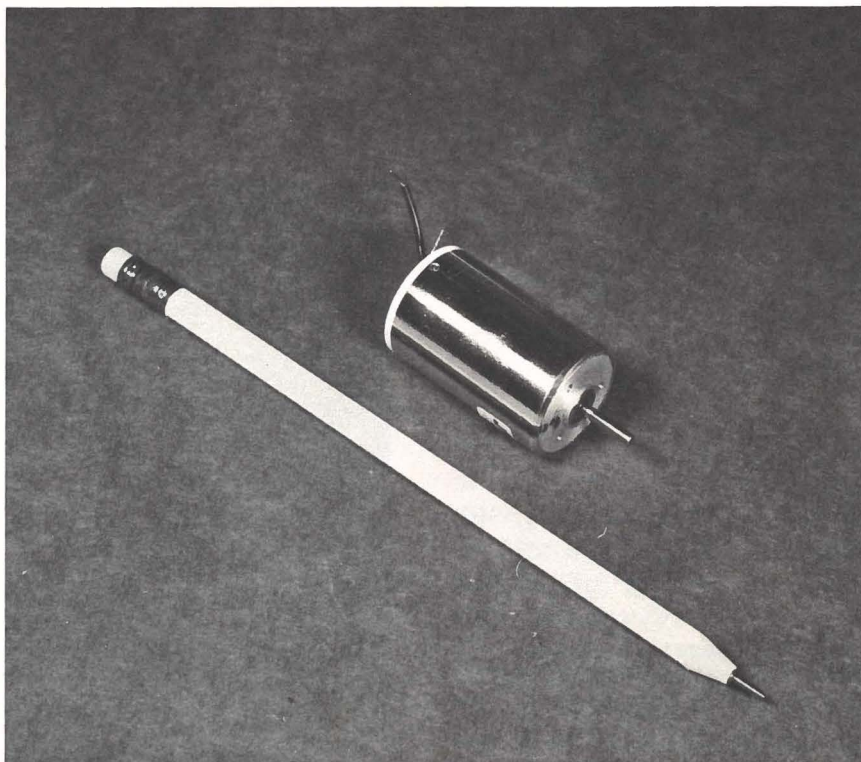
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Fig. 7. D-C capstan motor.

D-C Motors. Fig. 7. shows a d-c motor used to drive the capstan of a large 3/4″ editing machine. Despite its small size it develops considerable torque over a wide range of operating speeds. Editing machines must drive tape at speeds ranging between twice normal speed to 1/20th normal speed to assist the editor in locating specific edit points in the program. Although d-c motors first made their appearance in portable battery-powered VTRs, they are now used in many systems due to their small size, high torque, wide speed range, and easy incorporation into solid-state servo systems. The disadvantage of d-c motors is the electrical arcing and mechanical wear associated with armature commutation.

The d-c motor makes use of a steady-state field. In many cases the field is provided by permanent magnets. Rotational torque is achieved by switching the direction of current flow in the rotating armature. The basic principle is shown in Fig. 8. Here the armature consists of a single loop of wire suspended to rotate between the poles of a horseshoe magnet. Consider the conductor at the left of the diagram, at the 9 o'clock position. Current flowing in this wire sets up a field as shown. The field of the wire aids the field above the wire but cancels it below. The resulting action to shorten flux lines acts to push the wire down. Thus the loop turns counterclockwise. As this loop rotates past a half turn the action of the commutator causes
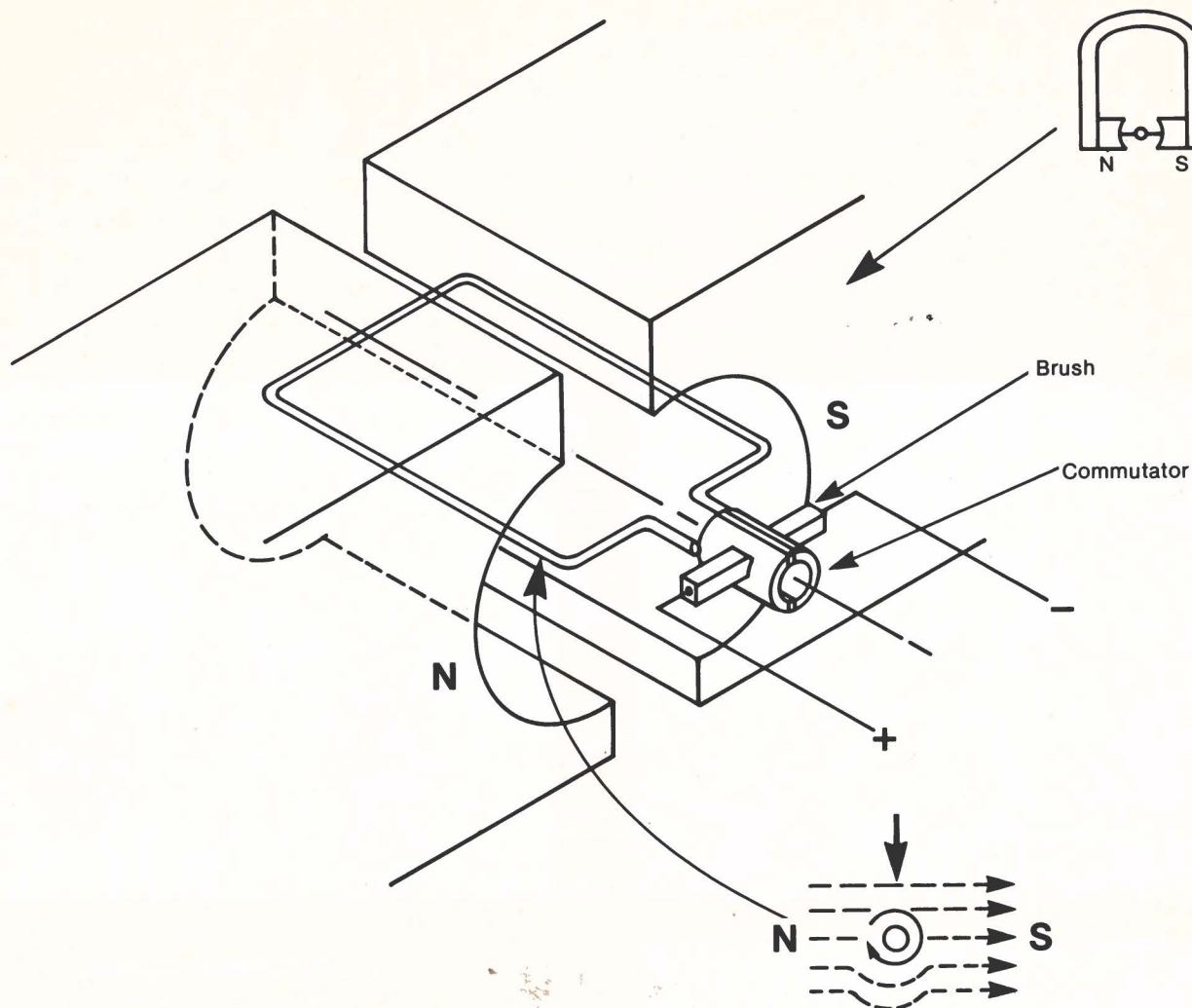
Fig. 8. Principle of d-c motor actions.

current to reverse in the loop. Now the field interaction acts to move the loop upwards. The mechanical switching action of the commutator keeps current flowing in the same direction in that part of the loop opposite either pole face. Thus the force on either half of the loop acts to turn the loop counterclockwise.

Counter emf. As the conductors cut the field flux a voltage is induced in the armature windings that acts to buck the applied voltage. This counter emf is directly proportional to motor speed. A motor operating without a mechanical load will draw very little current from the power source. Increase the load to slow the motor and counter emf drops. The result is an increase in armature current and greater torque. When the motor is stalled, no counter emf is developed

and armature current and driving torque reach a maximum.

Large industrial d-c motors can be connected with the field windings and the armature winding either in series or parallel. The series connection yields a motor with very high starting torque because both field and armature current are at a maximum when the motor is stalled. The shunt connection has less starting torque but much better speed regulation, due to the action of counter emf which allows more armature current to flow as mechanical loads increase. Motors with PM (permanent magnet) fields, such as those used in VTRs, have characteristics similar to those of shunt-connected motors.
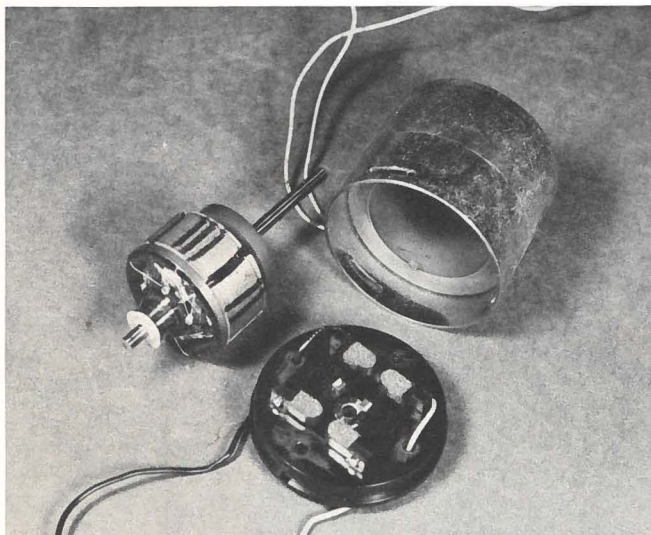
Fig. 9. D-C motor disassembled.

Fig. 10. "Coreless" d-c motor.

Fig. 9. shows a d-c motor disassembled to show the PM field, armature, commutator and brush assembly. The armature is made of laminated soft steel sheets that form a low reluctance path for magnetic flux. Armature coils are wound on the five core sections and the leads are brought out to the five section commutator. The brushes are small graphite blocks cemented to a pair of flat berylium-copper springs that apply brush pressure to the commutator. The placement of the brushes is critical as adjacent segments of the commutator are shorted when the brush bridges the gap. The brushes are in the correct position when the armature windings shorted by the brushes are those that are moving parallel to the flux field, and hence have no voltage induced in them. The correct plane for the brushes to operate in can be seen quite easily in the simplified drawing of Fig. 8. Note that when the
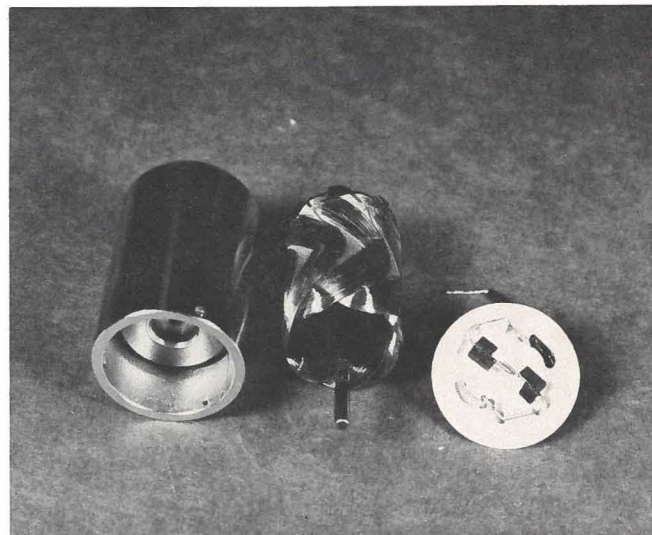
loop is straight up and down, and moving parallel to the flux field, the brushes will short the segments of the commutator.

Note the slots in the motor housing in Fig. 9. These permit the brush assembly to be rotated over a narrow range. The assembly is set for the proper brush plane. This results in maximum torque and minimum arcing at the brushes. Normally the motors used in VTRs are set correctly when the motor is assembled and adjustment of the brush assembly is not a regular service adjustment.

The motor shown in Fig. 10. is said to be a "coreless" type. The armature consists of windings only, formed into the shape of a hollow cylinder. It is not really coreless. The core, in fact, is stationary and the armature winding rotates in the space between the central "core" and the outside "field" pieces.
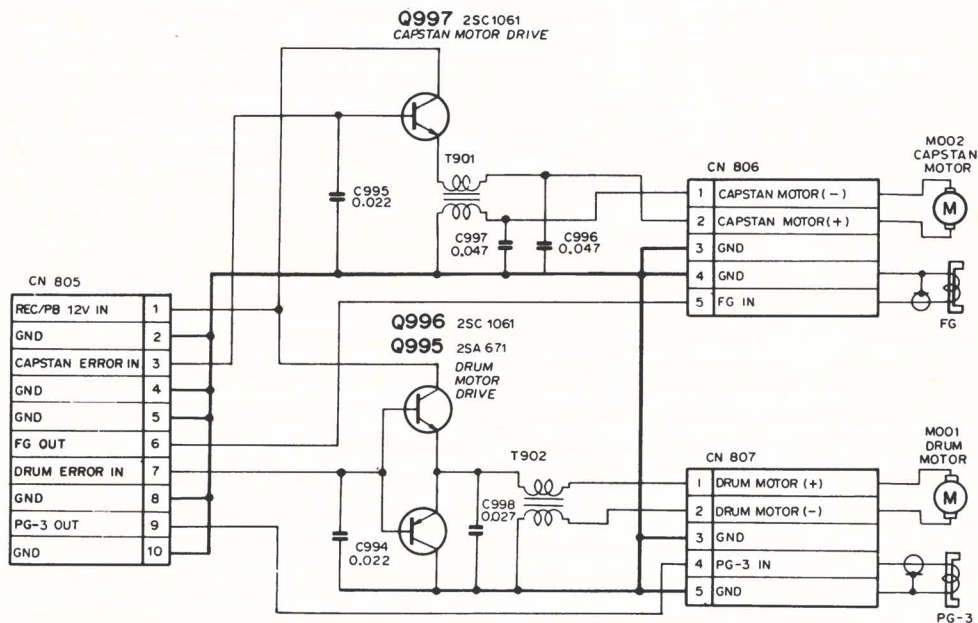
Fig. 11. D-C motor-drive amplifiers. (V0-3800)

Servo Control. D-c motors lend themselves to servo control because torque and, hence, speed, is directly proportional to armature current. Fig. 11. shows motor drive amplifiers from the Sony portable V0-3800, a typical set of servo output stages. The capstan drive amplifier is a single class A transistor, while the drum drive system employs a PNP and NPN transistor in the single-ended push-pull connection. Bifilar-wound chokes in the feed to the motor armatures (T901 and T902), as well as the bypass capacitors shown in the circuit are to keep r-f hash generated at the motor commutators from getting back into the signal processing circuitry. Direct current control for both amplifiers shown in Fig. 11. is called "error in" and is developed by the servo system. The functions of servo control will be taken up in the next lesson.

Fig. 12. Direct-drive scanner uses built-in d-c motor.

Fig. 12. shows the disassembled scanner from a portable U-matic. In this unit, the rotating platform that supports the video head assembly is secured directly to the upper shaft of a 9-pole d-c motor.
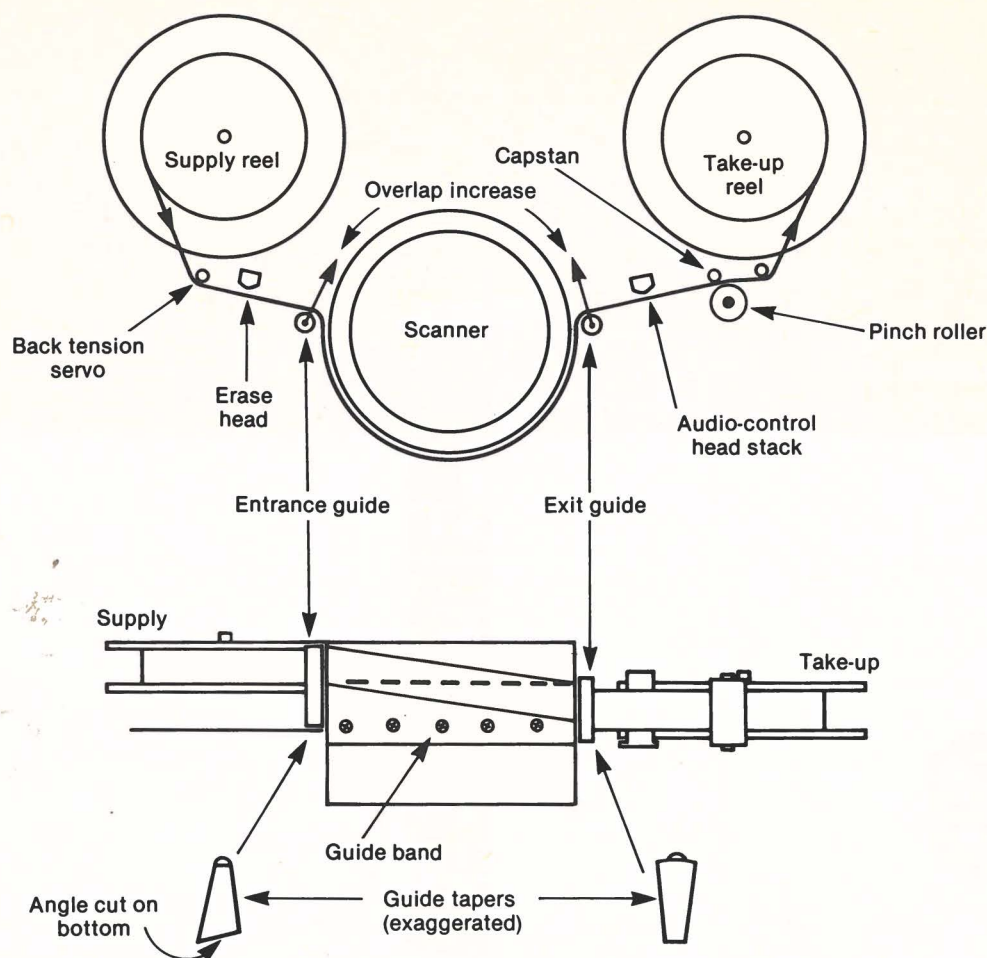
Fig. 13. Vertical scanner in early reel-to-reel machines.

2. TAPE GUIDANCE

The control of tape flow in audio recorders is simple and straightforward because the tape moves in a flat plane containing the supply and take-up reels, the capstan/pinch roller and the stationary heads. The situation is quite different in video tape recorders because tape must change altitude as it flows around the scanner. Not only must the tape be supported with great precision as it flows past the scanner and stationary heads, but the various guides in the tape path that alter tape altitude must be carefully adjusted so that tape does not curl or crease.

In early helical-scan machines, the scanner axis was made perpendicular to the plane of the machine chassis, as shown in Fig. 13. Tape flowed down around the scanner as shown, and the top panel had a stepped configuration with

the supply reel higher than the take-up reel. In this system, tape had to change direction twice in the vertical plane, first at the entrance guide where tape starts to turn downwards, and then at the exit guide, where tape straightens out to cross the stationary heads and enter the capstan-pinch roller combination. Adjustment of the entrance and exit guides is extremely critical for two reasons. First the angle that the tape-bearing surface of the guide makes with the chassis determines the angle the tape takes with respect to the chassis. This angle must be set so that the lower edge of the tape meets the guide band on the scanner at precisely the right altitude. To facilitate adjustment the bottom of the guide is machined at an angle to the guide axis. Thus, rotating the guide acts to change the angle at the tape-bearing surface. The second

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degree of freedom in the entrance and exit guide mounts is permitted by the mounting hole in the chassis, which is somewhat larger than the diameter of the machine screw that secures the guide to the chassis. By moving the guide in the direction shown by the arrow in the top view, the scanner wrap angle is increased and overlap is also increased. Thus the two tapered guides at the entrance and exit of the scanner have to be adjusted with great care.

During manufacture, mechanical fixtures are used to locate the guides and set rough angles. But the final adjustment is made using a prerecorded precision standard tape. Final adjustments are then made to obtain a flat r-f envelope during playback of this precision tape. An r-f envelope that meets the tolerance for flatness, as shown in Fig. 14. has the tape at the right altitude at all points of scanner contact. In addition, the audio/control-track head stack is at the right distance downstream from the scanner.

While the entrance and exit guides play the major role in determining tape altitude as tape enters and leaves the scanner, it must be remembered that other factors can affect tracking by causing errors in tape altitude either before or after these key guides. On the input side, for example, an error in the perpendicularity of the erase head can cause tape to flow upwards or downwards as it approaches the entrance guide. The same is true of the tape guide mounted on the tape-tension arm that actuates the back tension brake. This post, mounted on a relatively long and movable arm is vulnerable to damage due to accidental bending.

At the exit side of the scanner, a tilt of the audio/control track stack can also act to change the direction of tape flow. For example, if the top of the head stack were tilted downwards as shown in the lower part of Fig. 13. tape would be forced downwards at this point. Another factor is the parallelism of the capstan and pinch roller. Unless the pressure applied by the pinch roller is uniform across the width of the tape,
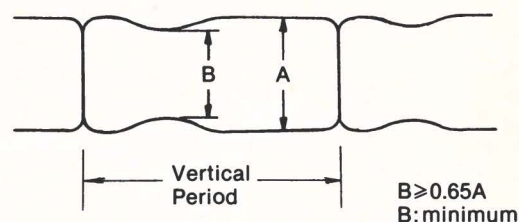

Fig. 14. R-F envelope tolerance.

the pinch roller can act to drive tape upwards (too much pressure on the bottom) or downwards (too much pressure on top). A change in tape altitude that grows with time, ending with tape curl at some stationary guide point is symptomatic of this form of error. Finally the height of the reels themselves must be correct to ensure that tape starts out and ends up at the correct altitude. Reel-table height is adjusted by adding or removing shim washers to the spindles on which the reel tables rotate.

Before we leave Fig. 13. make note of the positions of the stationary heads in the tape path, as the sequence with which tape passes each unit is common in all VTRs. The erase head stack is located on the entrance side of the scanner, between the entrance guide and the hold-back tension servo. The erase head is not found in playback-only machines. It is usually a full-track erase head capable of erasing tape from edge to edge. However, in machines that offer audio dubbing to prerecorded video, a separate erase head can be activated to erase one audio track only.

The audio/control-track head is located between the exit guide and the capstan. This head stack records and plays back audio signals as well as the servo timing signals employed by the scanner servo system. In some machines the control track signals are used for servo control of capstan speed.
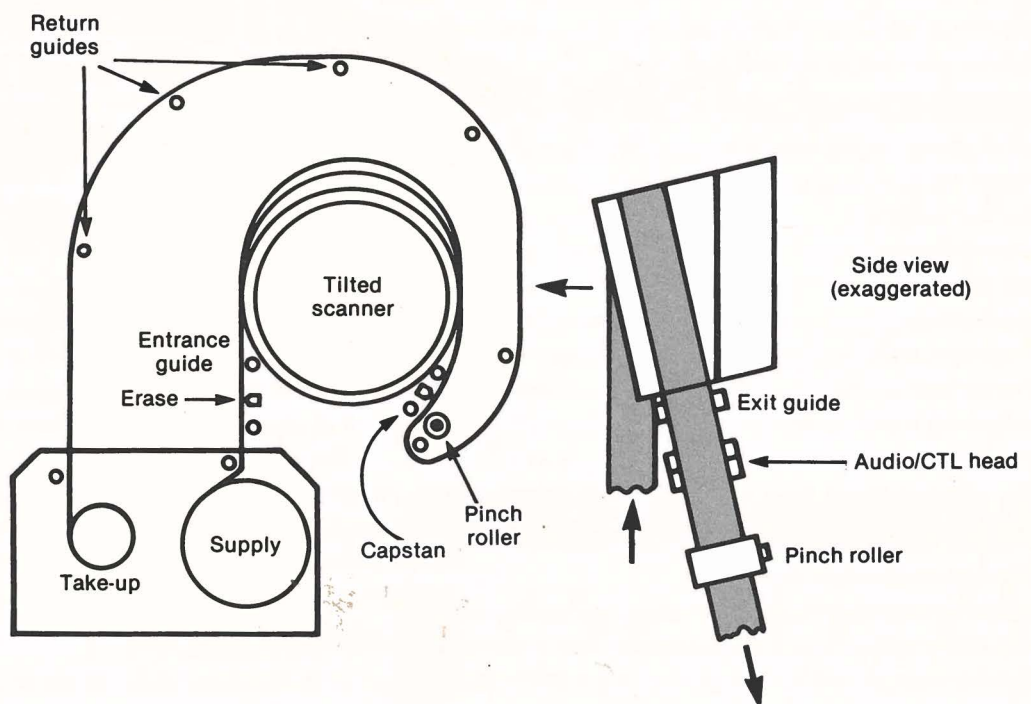
Fig. 15. Tilted scanner in modern VTR.

Modern Helical Scan Machines. A glance at more recent VTRs, such as the U-matic and Betamax reveals a basic change in the tape path. Fig. 15. shows the tape path for early U-matic machines. The first thing that should be noted is that the axis of the scanner is not at right angles to the chassis. Second, tape flows straight out of the cassette and flows towards the scanner without a change in altitude. This design was born of practical experience with early machines. It was found that large wrap angles at stationary guides tends to introduce longitudinal vibration due to stiction that translates into short-term time-base error. Thus, later designs make use of direct entry paths into the scanner area, with relatively small wrap angles at the stationary guides in this part of the tape path.

Tape flows down around the tilted scanner and emerges in a straight line passing the audio/control-track head stack and the capstan/pinch roller, both of which follow the downward direction of tape flow. It isn't until the tape has passed the capstan/pinch roller that stationary guides begin to angle tape upwards on its return path to the take-up reel. But the capstan/pinch roller acts to isolate the action of these guides from the critical scanner area. The guides following the capstan/pinch roller are angled to gradually return tape to the altitude of the take-up reel.
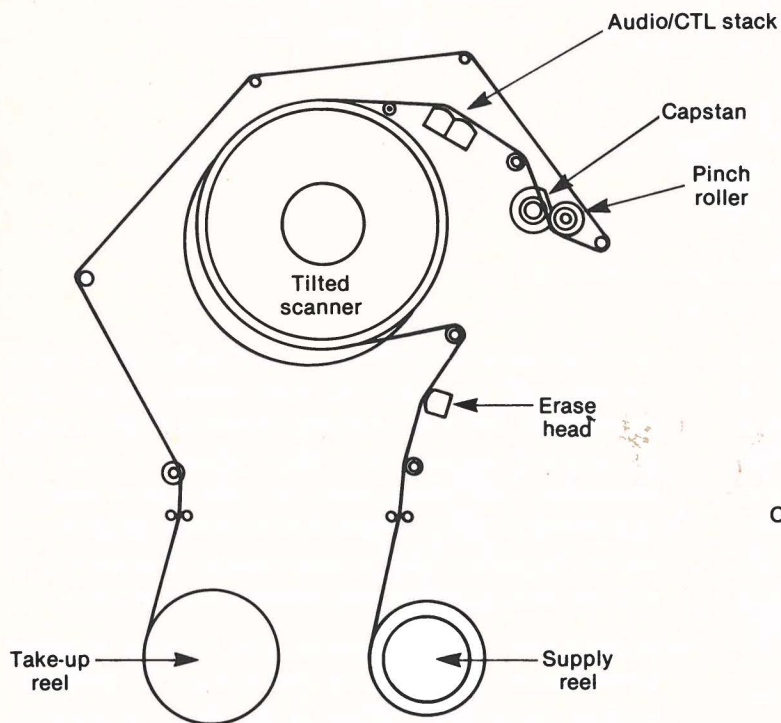
Fig. 16. U-matic Type II tape path.

Fig. 16. shows the tape path for the type II U-matic and Fig. 17. shows that of the Betamax. Note that the relative positions of supply and take-up reels are reversed in the Betamax.

Reel table height is somewhat more critical in cassette machines because the reel table must lift the reel hubs inside the cassette clear of the floor of the cassette. In addition, altitude must be correct as the tape leaves the cassette.
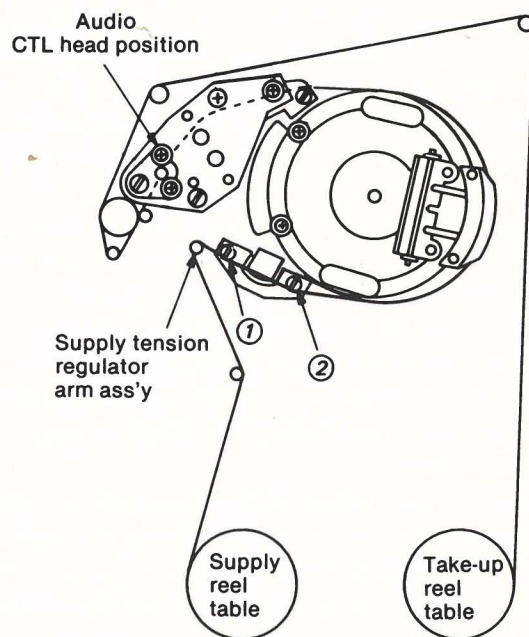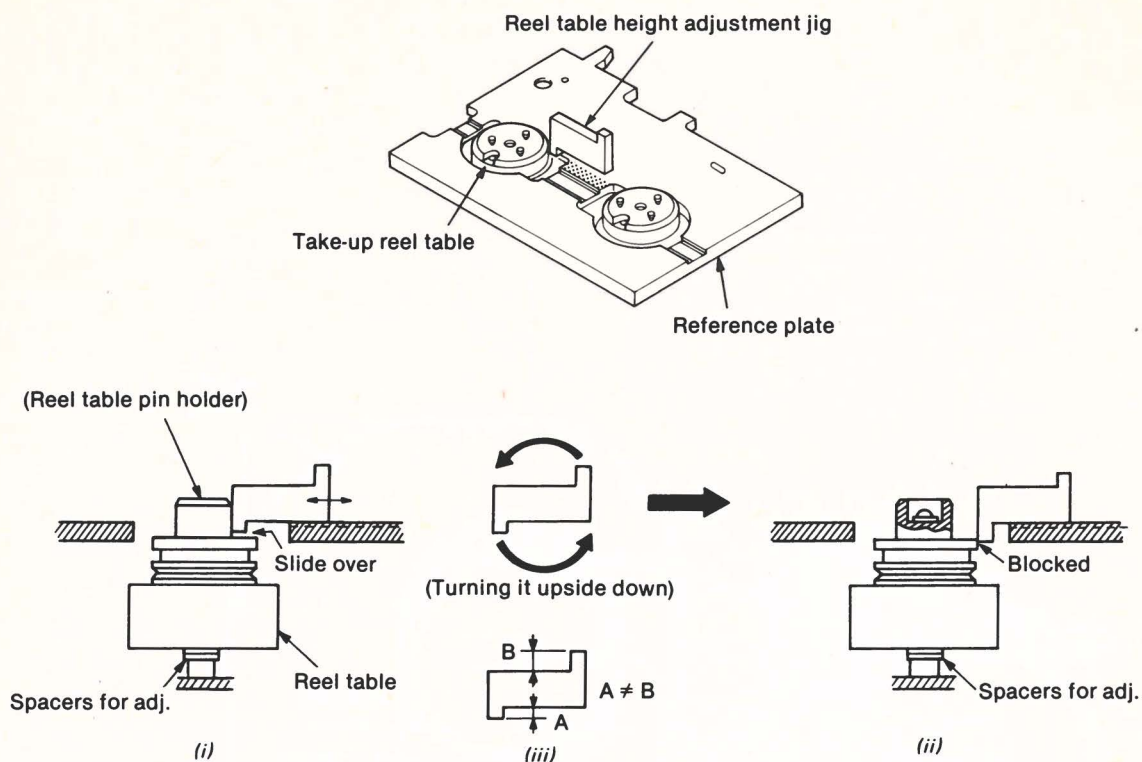

Fig. 17. Betamax tape path.

Fig. 18. Checking reel-table height.

Checking Reel Table Height. This job requires two mechanical fixtures (jigs). The first is a reference plate that conforms to the bottom of a cassette. It is placed on the four posts that serve to support the floor of the cassette the specified height above the chassis. A two-step go-no go gauge is then used to measure the height of the top of the reel table. The gauge is placed on the reference plate as shown in Fig. 18. and positioned as shown. The gauge is then turned over (end-to-end) and the test repeated. If the reel table height is correct, the gauge will clear the shoulder of the reel table in one case and be blocked by it in the other. This shows that the reel-supporting shoulder of the table is within proper tolerance. Height is adjusted by adding washers beneath the reel table assembly, as shown.

Fast Forward and Rewind. In addition to tape drive applied via the capstan during forward record or play operations, facility must be provided to advance tape rapidly and to rewind tape back onto the supply reel. In open-reel and Betamax machines both fast-forward and re-

wind are accomplished while the tape is threaded through the normal tape path. In U-matic machines, tape is unthreaded and fast-forward or rewind operations take place inside the cassette. An exception is the later type II U-matics in which tape is withdrawn slightly so that it bears against an address/CTL head-stack during fast-forward and rewind operations.

During fast-forward operations, drive is applied to the take-up reel table. For industrial and consumer machines, drive is applied via rubber-tired idlers driven from the main motor. The slip clutch built into the take-up reel table is bypassed by the reel drive system. In those machines wherein tape remains in the tape path the pinch-roller is withdrawn from the capstan during both fast forward and rewind operations.

During rewind operations an additional rubber-tired idler is engaged between the source of rotating torque and the supply reel to drive it in reverse. A typical reel-drive system is shown simplified in Fig. 19. This is the system used in an early Betamax.
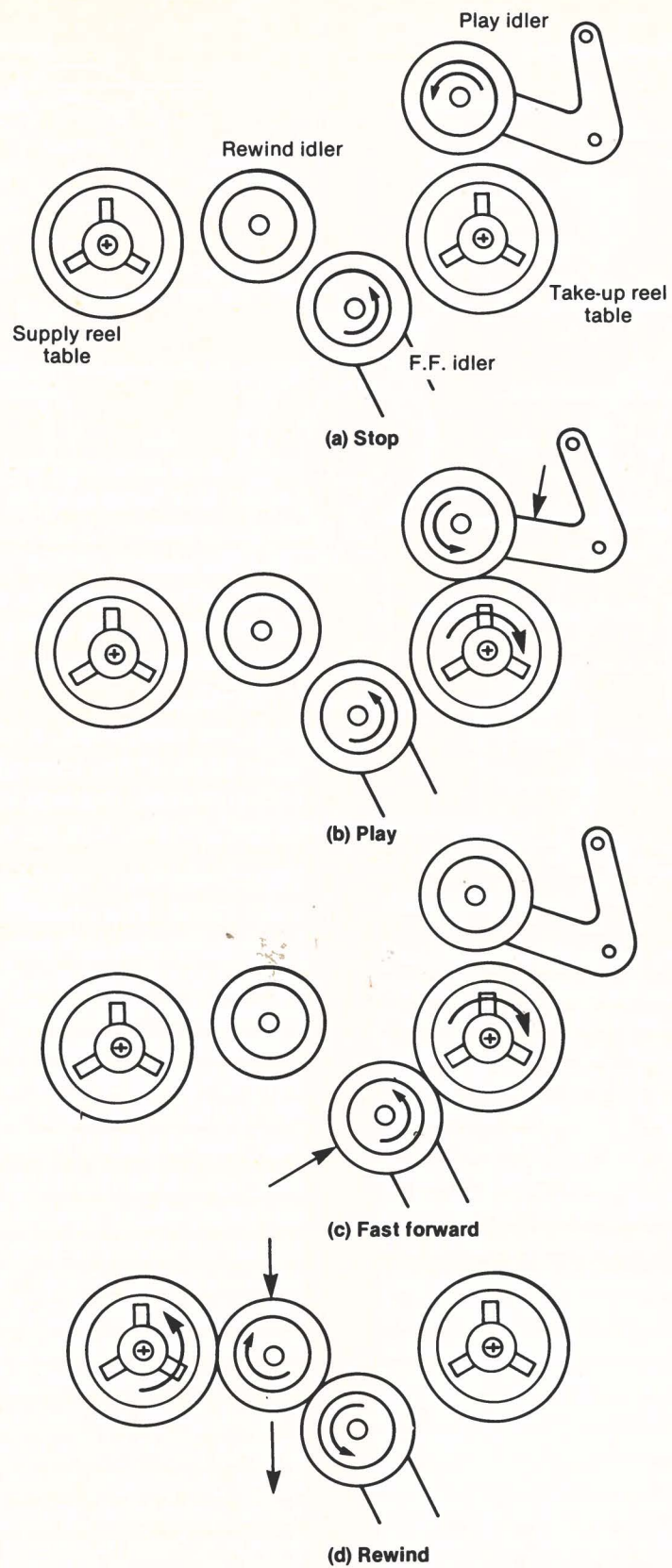
Play idler

Rewind idler

Supply reel
table

Take-up reel
table

F.F. idler

(a) Stop

(b) Play

(c) Fast forward

(d) Rewind

Fig. 19. Idler drive to reel tables in SL-6200 Betamax.

Fig. 20. Typical hold-back tension brake.
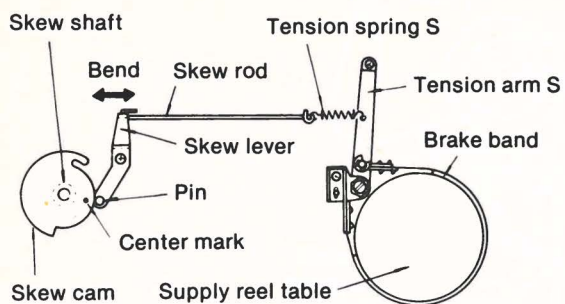

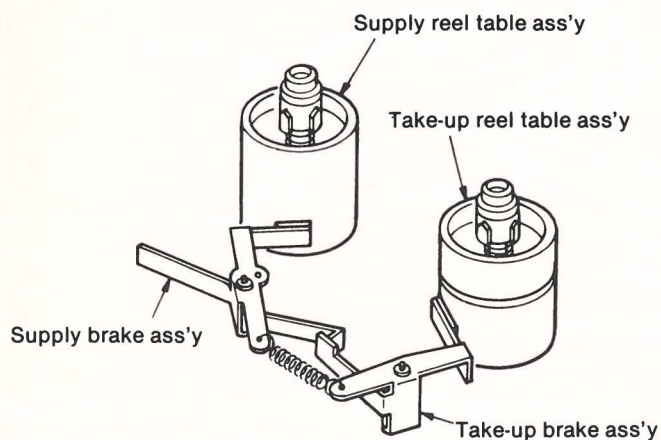Fig. 22. Brake applied to supply reel provides back tension during rewind.

Fig. 21. Stop brakes (SL-6200).

Reel Brakes. Brakes are applied to the reel tables to establish proper tensions during operating modes and to lock the reels, and kill the effects of reel inertia when the machine is switched from an operating mode to the stop mode.

Fig. 20. shows a typical hold-back tension brake to provide hold-back tension in the forward (play) mode. The brake band on the supply-reel table is controlled by a purely mechanical servo that senses tape tension at the input side of the scanner. It acts to increase braking action if tape tension decreases at the point where tape rides against the post on the tension arm. This servo compensates for the steady increase in back tension that results from the shrinking tape-pack diameter as tape advances. Note that
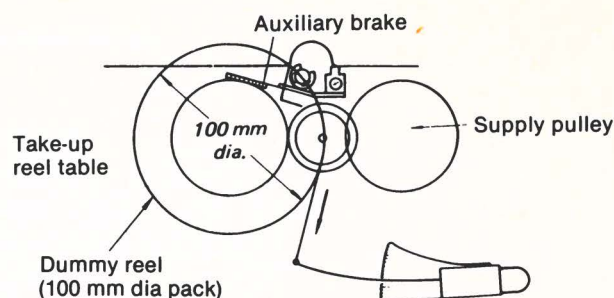
the spring attached to the tension arm does not return to a fixed anchor but to a movable anchor whose position is determined by a cam linked to the front-panel SKEW control. When the control is set to mid range, the arm attached to the skew rod is bent to the left or right to develop the required back tension (70 to 90 grams for the U-matic).

In some machines, a similar tension-brake servo is used at the take-up reel table. This applies uniform back tension for the take up reel, which in the U-matic has no lower flange.

Stop brakes are applied to both reel tables in the stop mode. The brakes are released by solenoid or mechanical linkage to the function buttons during the operating modes. Fig. 21 shows the stop brakes of an early Betamax machine. Both brakes are released simultaneously in the forward mode by a solenoid. The brakes are released by means of linkages to the mode keys in fast-forward and rewind operations.

In addition to the stop brakes, auxiliary brakes are sometimes used on the supply reel table of cassette machines to establish correct hold-back tension during threading operations. In some cases, a momentary brake is applied at the end of the thread cycle to kill the inertia built up in the rotating supply reel at the end of the thread cycle so that a loop of tape cannot be thrown out into the tape path. Another auxiliary brake is applied to the take-up reel during rewind operations to maintain uniform back tension and help to secure a tight and uniform tape pack on the supply reel at the end of rewind operations. Fig. 22 shows such a brake.
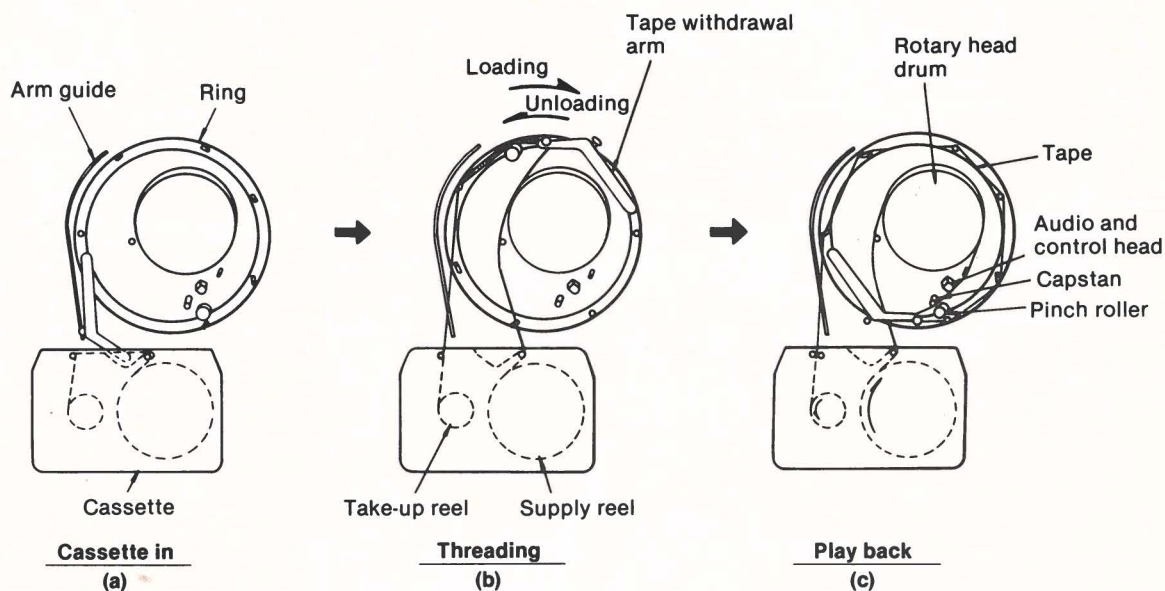
Fig. 23. Type I U-matic threading system.

3. TAPE THREADING

Automatic tape threading and unthreading operations add to the electrical and mechanical complexity of cassette machines. In addition, because tape flow is out of sight of the operator, automatic provision must be made to stop tape travel when end of tape is reached in either forward or rewind operations. Constant monitoring is also needed to guard against serious machine damage should tape fail to be taken up by the take up reel, either due to a loss of drive to that reel or a break in tape following the capstan/pinch roller. Such failures must trigger automatic machine shut down or the machine would actually fill up with tape.

All Sony cassette machines make use of a rotating threading ring to pull out a loop of tape from the cassette and draw it around the scanner and into the proper tape path.

Fig. 23. shows the system employed in the Type I U-matic. When the cassette drops into place the post on the pivoting tape withdrawal arm is inside the V-shaped notch at the front edge of the cassette and behind the short length of tape that spans the distance between guide posts inside the cassette. Selecting the play or forward mode starts the d-c threading motor which turns the threading ring clockwise as shown in (b) of the figure. As the loop is withdrawn the pinch roller, which is mounted on an arm secured to the threading ring, comes up inside the loop and follows the arm around until the ring completes its cycle. At that time the pinch roller is opposite the capstan and an external yoke applies pressure to push the pinch-roller against the capstan. During the threading mode the stop brake is released from the supply reel so that it supplies tape to form the loop. During the unthread cycle, which is triggered by manually or automatically initiating the stop mode, the pinch roller is released and the threading ring is driven to turn counterclockwise. The supply reel is then braked and the loop absorbed by the driven take-up reel.
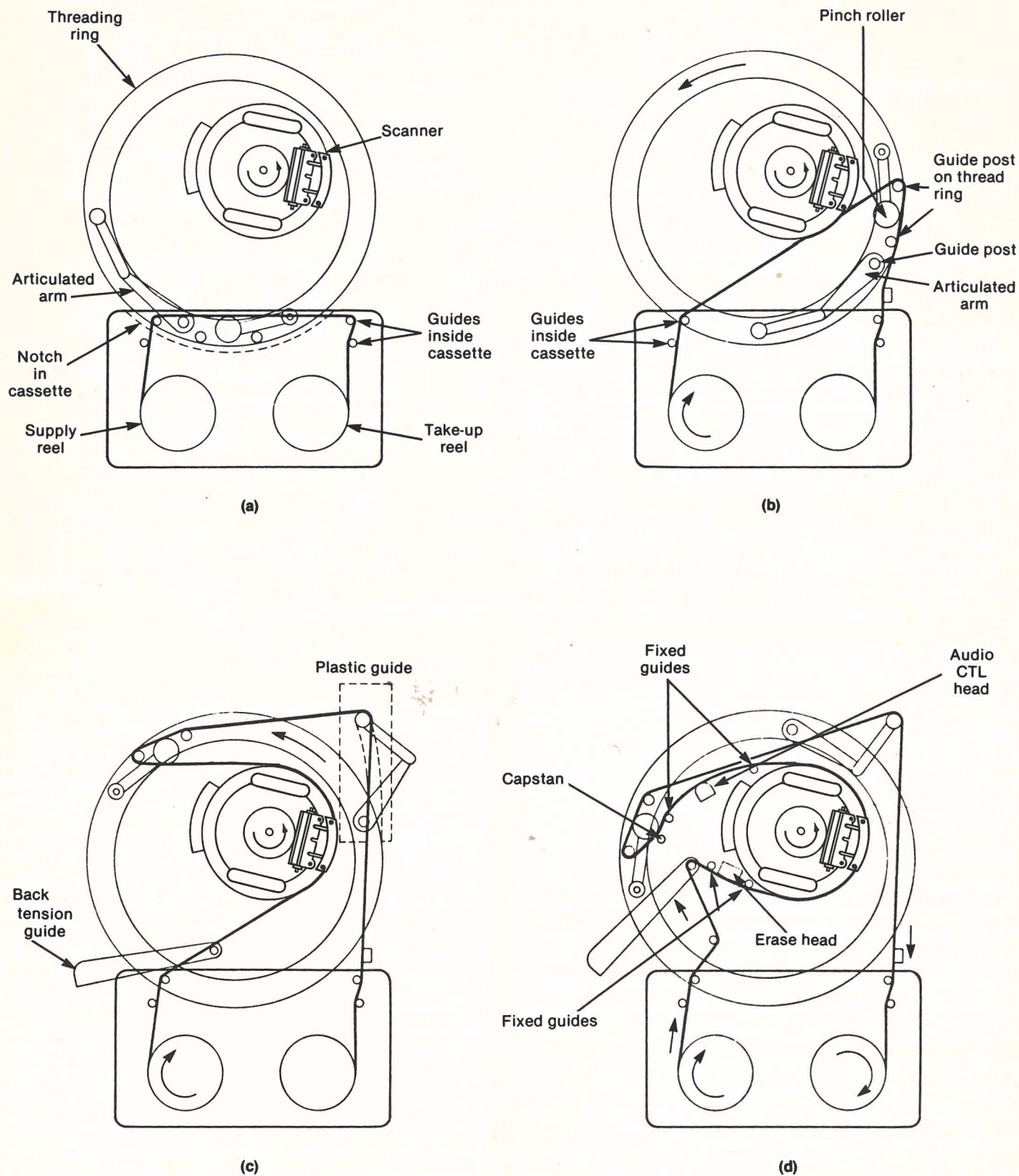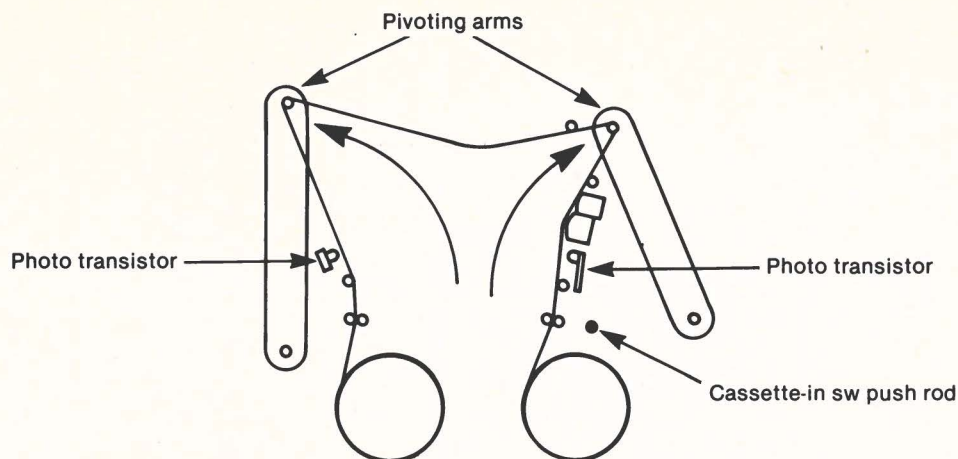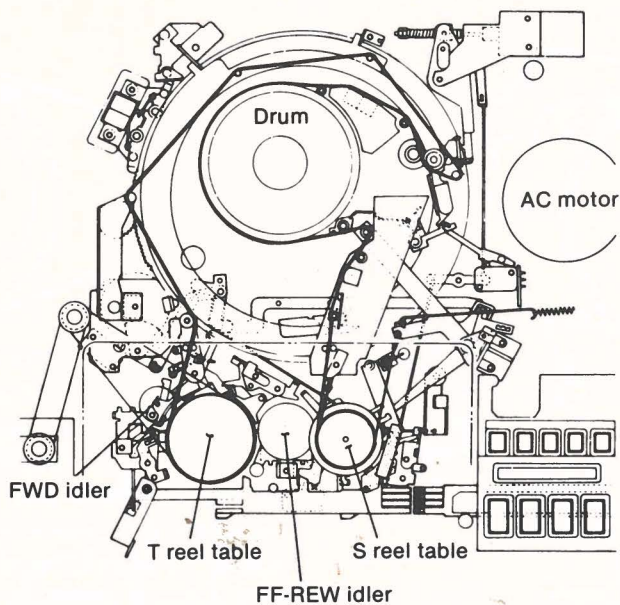
(a)

(b)

(c)

(d)

Fig. 24. Betamax tape-threading system.

Pivoting arms

Photo transistor

Photo transistor

Cassette-in sw push rod

(a) Partial threading (cassette in).

Drum

AC motor

FWD idler

T reel table

S reel table

FF-REW idler

(b) Full threading (play).

Fig. 25. U-matic Type II threading system.

Fig. 24. shows the basic system used in Betamax machines. Note that the positions of the supply and take-up reels are reversed (from left to right) as compared with the U-matic. The threading ring turns counterclockwise to thread tape. When the cassette drops into place both the post on a pivoted arm and the pinch roller are inside the notch at the front edge of the cassette and behind the span of tape between internal guide posts. As the loop is pulled out the top of the post on the pivoted arm gets trapped in the track of a plastic guide. The arm jack-knifes as it passes the guide and a claw traps the post at the end of the plastic track. The cycle is completed when the pinch roller arrives opposite the capstan. Unthreading reverses the action of the threading ring. A cam on the lower surface of the threading ring releases the claw that holds the post of the pivoted arm trapped at the end of the plastic guide.

A variation is applied in the Type II U-matic machines whereby the tape is partially threaded, by means of a pair of arms, when the cassette is loaded. See Fig. 25a. This places tape against the erase/address head stack in all operating modes, and permits the read out of frame-pulse information for editing purposes in fast forward, rewind, as well as forward modes. A threading ring completes tape threading for forward operations as shown in (b) of the figure.
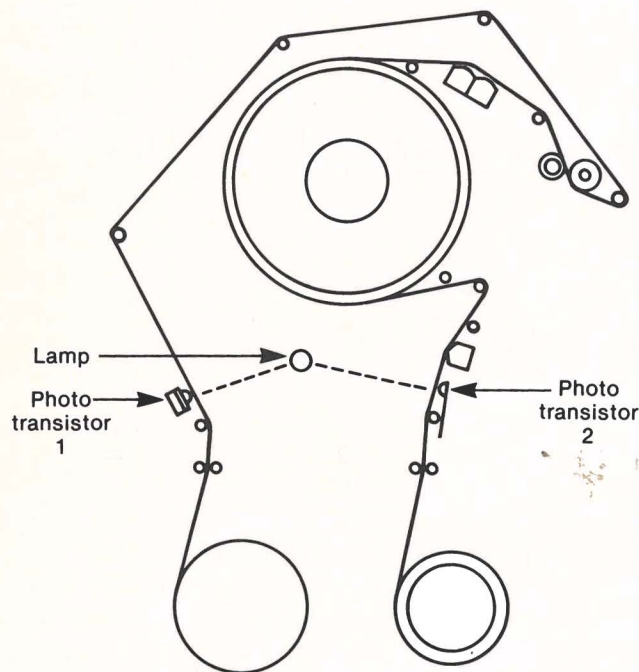
Fig. 26. End-of-tape photo transistors and light source in Type II U-matic.

Lamp

Photo transistor 1

Photo transistor 2

Fig. 27. End-of-tape sensing coils detect metal-foil leaders in Betamax.

Take-up sensing coil

Supply sensing coil

Video tape

Leader tape

Supply reel table

Take-up reel table

End-of-Tape Sensing. End of tape is detected in U-matic machines by means of photo transistors and associated light sources. See Fig. 26. Each end of the tape is secured to the appropriate reel in the cassette by means of a clear plastic leader. When light is permitted to pass through the leader the appropriate photo transistor is exposed and an automatic stop function is triggered. The system control circuits actuate the appropriate photo transistor to sense the end of tape in either forward or rewind operations.
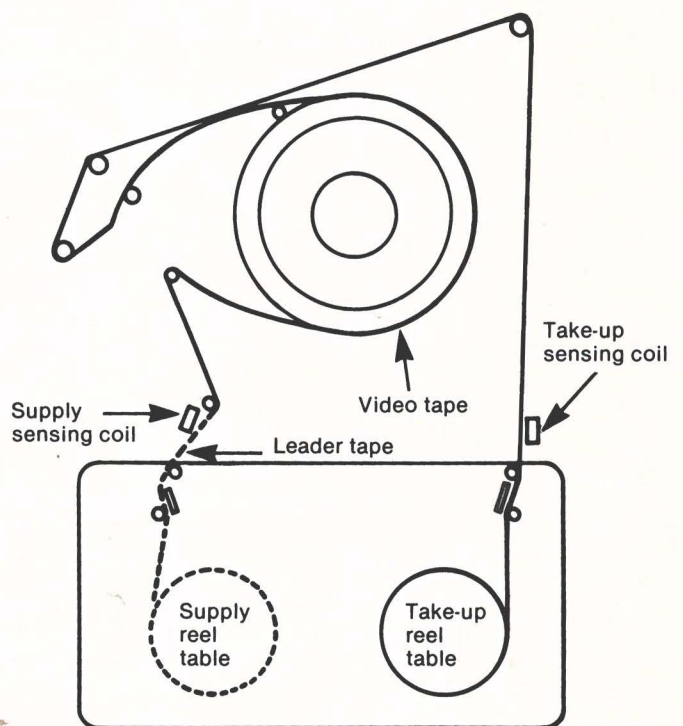
The Betamax system employs a leader made of conductive metal foil. The sensors in this system are the coils of an oscillator, as shown in Fig. 27. Proximity of the foil leader opposite the sensing coil acts like a short-circuit secondary winding of a transformer in which the primary is the sensing coil. The effect is to lower the Q of the oscillator tank circuit and kill oscillation. The drop in r-f drive to a peak rectifier develops the logic control voltage that triggers auto stop.

Slack Tape Sensors. Auto stop is initiated by any fault that would prevent the tape being metered out by the capstan/pinch roller from being accumulated by the take-up reel. In some machines, the rotation of the take-up reel is monitored. In others a lamp-photo cell arrangement is used wherein the loop formed by slack tape at the output of the capstan blocks the light path to the photo cell. Fig. 28. shows the simple slack-tape detector used in a Betamax deck. It is a spring loaded post that rides against the tape at the point where tape has exited the capstan/pinch roller and is on its way back to the take-up reel. Slack in the tape permits the arm to move as shown by the arrow and the cam rides off the microswitch roller, allowing the switch to be tripped.

Mechanical feelers of this type also monitor tape slack in U-matic machines.

All in all the tape transport of a modern helical scan VTR is somewhat forbidding in terms of mechanical complexity. However the basic concepts are the same and the experienced technician quickly learns to recognize and identify basic functions within the maze of solenoids, linkages and power-driven assemblies.
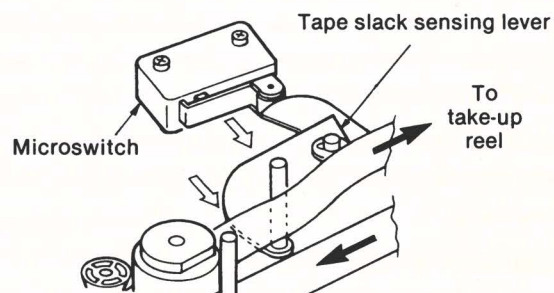

Fig. 28. Simple slack-tape detector.

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Glossary of Tape Transports

Armature—The moving element in an electro-mechanical device, such as the rotating part of a motor.

Commutator—In DC motors, the part of the armature through which the armature coils are connected to the power source.

Counter EMF—The force generated by an electric field which is opposite in action to the originating field, in accordance with a physical phenomenon known as Lenz' Law.

DC-motor—A direct-current motor in which rotational torque is achieved in a steady-state magnetic field, by switching the direction of the current in the rotating armature.

EMF—Electro-motive force; the electric force generated in conductive materials by moving electric or magnetic fields.

Error-in—A feedback signal in a servo system corresponding to the deviation from a reference standard; used to correct device operation.

Field, Flux—Force (magnetic or electric) which exists between two unlike poles (or around a single pole) and can be visualized as lines of force flowing out of one pole to the other.

Hysteresis Motor—A synchronous motor that runs by the reaction of a permanent magnet rotor to a rotating field.

Induction Motor—An alternating-current motor in which power through the primary induces current in a secondary which is wound around the armature.

Non-synchronous Motor—A motor whose rotational speed is less than the line frequency, so that the conductor bars of the secondary winding will cut the rotating flux field.

R-F Hash—Noise and random oscillations in the high radio-frequency (r-f) range, resulting from switch bounce, commutator switching and other control instabilities.

Reluctance—The resistance of a material to align its magnetic domains with an external field; the inverse of permeability.

Servo, Controls—A feedback system of automatic controls.

Starting Torque—the ability of a rotating object, such as a motor shaft, to start from rest.

Stator—The non-rotating part of the magnetic field structure in an induction motor. These coils (field winding) contribute to the magnetic fields which react with the rotor.

Synchronous Motor—A motor whose rotational speed is synchronized to the line or power source frequency.

Threading—The mode of operation in a VTR where tape from a videocassette is automatically positioned around the tape path.

Torque—Force applied around an axis, in a rotational, angular manner; also called the moment of force.

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1. Tape speed in the forward mode is determined by the speed and diameter of the: (a) take-up reel; (b) scanner; (c) capstan; (d) threading ring.

2. During the rewind mode, motor torque is applied to the: (a) supply reel; (b) take-up reel; (c) capstan; (d) pinch roller.

3. In the forward mode, torque is applied to the take-up reel: (a) directly; (b) through a speed regulator; (c) through a slip clutch; (d) in reverse.

4. An effect that results from a difference in hold-back tension between the machine that made the recording and the machine that is playing it back is called: (a) skew error; (b) dihedral error; (c) CTL jitter; (d) mistracking.

5. Skew error is most visible; (a) in color recordings; (b) at the video head switching point in the picture; (c) at the top of the picture; (d) when the picture is out of sync horizontally.

6. In industrial and home VTRs, hold-back tension is regulated by: (a) a mechanical servo; (b) a variable slip clutch; (c) control of capstan speed; (d) a time-base corrector.

7. A typical value for hold back tension is: (a) 0.7 grams; (b) 7 grams; (c) 70 grams; (d) 700 grams.

8. Back tension tends to be higher in the forward mode: (a) when the supply reel is full; (b) when the skew control is at mid range; (c) when the tape has played halfway; (d) at the end of tape.

9. Tape speed is constant in the: (a) fast-forward mode; (b) rewind mode; (c) play mode; (d) pause mode.

10. Tape tension is measured using: (a) the alignment tape; (b) by gauging the skew error on the monitor screen; (c) by checking tape tension with a tension gauge with tape pulled at normal speed; (d) by measuring the force applied to the tension brake band.

11. A reel pack of 80 mm diameter exerts a take-up tension of 200 grams. The torque applied to the reel is: (a) 1600 kilogram centimeters; (b) 1.6 kilogram centimeters; (c) 0.8 kilogram centimeters; (d) 800 kilogram centimeters.

12. An eight-pole two-phase hysteresis motor operating from 50 Hz power mains turns at: (a) 1800 rpm; (b) 30 rps; (c) 50 rps; (d) 25 rps.

13. Increasing the number of poles per phase in a two-phase hysteresis motor acts to: (a) increase torque; (b) increase speed; (c) decrease torque; (d) decrease speed.

14. D-c motors used in industrial and home VTRs employ: (a) series-connected fields; (b) shunt connected fields; (c) electronic commutators; (d) PM fields.

15. Servo control of d-c servomotors is achieved by controlling; (a) armature current; (b) field current; (c) armature frequency; (d) brake current.

16. The electromagnetic brakes used in scanner braking servos are similar to squirrel cage a-c motors except that: (a) line voltage is applied to the field; (b) direct current flows in the field winding; (c) there is no commutator; (d) the field rotates in the brake coil.

17. The spindle of the scanner is perpendicular to the chassis in: (a) EIAJ AV-series machines; (b) U-matic type I machines; (b) U-matic type II machines; (d) Betamax machines.

18. Overlap is determined in part by the locations of the: (a) erase head; (b) capstan/pinch roller; (c) entrance and exit guides; (d) audio/control head stack.

19. Metal-foil leaders act to trigger automatic stop in: (a) Betamax machines; (b) Type I U-matics; (c) Type II U-matics; (d) EIAJ AV-series machines.

20. The slack tape sensor is triggered when: (a) hold-back tension is too low; (b) the scanner speeds up; (c) tape breaks; (d) the supply reel turns freely.

Answers:

1. c	6. a	11. c	16. b
2. a	7. c	12. d	17. a
3. c	8. d	13. d	18. c
4. a	9. c	14. d	19. a
5. b	10. c	15. a	20. c

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